MICHIGAN STATE UNIVERSITY

Department of Entomology

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Session on Pre-release Evaluation of Candidate Microbial Biological Control Agents:

Attributes for Predicting Efficacy and Benefits of Microbial Agents

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- **What is your perception of risk?**

Discussion Topics

- Determining native range of target species, and appropriate places to collect microbial agents (Briano);
- Climate matching of host and microbial agents (Lacey);
- Physiological *vs.* ecological host range (Bruckart);
- Host-specificity testing (Berner); and
- Inter-microbial agent interactions (Stockwell).

- Risk analysis; and
- Post-release monitoring.

What is the Context?

Improving biological control science:

- What procedures are needed to ensure that native ranges of target pests are identified and sampled?
- How can physiological (laboratory) host-specificity tests be structured to enable a testable hypothesis prediction of ecological (field) host range?
- What aspects of agent and host ecology must we know?

Informing regulatory decisions:

- What data would be useful and convincing to facilitate proper, science-based regulatory decisions?

What is the Context?

Risk Analysis:

- Dealing with the Worst-case Scenario.
- Risk is “The possibility of an adverse outcome, and uncertainty over the occurrence, timing or magnitude of that adverse outcome" (Covello and Merkhofer 1994).
- Risk is Hazard x Exposure.

Covello, V.T. and Merkhofer, M.W. 1994. *Risk Assessment Methods*. Plenum Press, New York. 319 pp.

R = H x E

- But what is hazard;
- What is exposure;
- How are they measured; and
- Do they have any predictive value for ecological host range?

Hazard and Exposure

Hazard

- Hazard is *the ability to cause harm*, and is an *innate characteristic* of the taxon; but
- The *expression* of harm is mediated by environmental factors ("sieves").

Exposure

- The *potential harm*, mediated by environmental factors;
- Exposure acts upon hazard.

Host Range and Risk to Non-target Species

Physiological Host Range (PHR)

- Potential or laboratory host range, estimated by host-specificity testing (= risk assessment).
- Should be maximized by testing, even if it requires extremely artificial conditions.
- A key "sieve" in the relatedness testing procedure and in estimating exposure in the risk equation.

Ecological Host Range (EHR)

- Actual or field host range, about which inferences can be made from results of the PHR.
- Always smaller than the PHR, and predictable from host-specificity testing.

Hypotheses

- Ecological host range can be predicted by physiological host-specificity data.
- Efficacy of host-specific natural enemies can be predicted.
- Benefits (economic, environmental, social) can be predicted.

What is Risk?

1. Hazard x Exposure;
2. The interaction of *innate characteristics* of a taxon and *environmental features* (sieves) that mediate the interaction;
2. A measure of the completeness of information; and
3. A measure of uncertainty.

Predictive Attributes

$R = H_i \times E_e$

Innate Characteristics	Environmental Sieves
❖ Potential host range;	❖ Susceptible hosts in the environment;
❖ Toxicity;	❖ Bridging species;
❖ Basic biological features; and	❖ Distribution;
❖ Capacity to interact with the environment.	❖ Phenology;
	❖ Ecology; and
	❖ Climatic conditions.

What is the "Worst-Case?"

- **You have only one promising microbial natural enemy for biological control of a major invasive weed.**
- **But … it attacks a rare, threatened, endangered native plant in the same subgenus as the introduced weed.**

The Cast of Characters

Heliotropium europaeum (common heliotrope)

- A summer-growing annual weed from Europe to North Africa.
- Causes millions of dollars of direct and indirect damage to Australian agriculture each year.
- Invades natural systems, poisons livestock, and competes with crops.
- No economic or environmentally sustainable alternatives exist for its management.

The Cast of Characters

Uromyces heliotropii (heliotrope rust fungus)

- A macrocyclic, autoecious rust fungus (Pucciniaceae).
- Found from *H. europaeum* in original surveys mid-19th Century.
- Thought to be specific to *Heliotropium*, but never tested.
- Single-spore culture used for all testing.

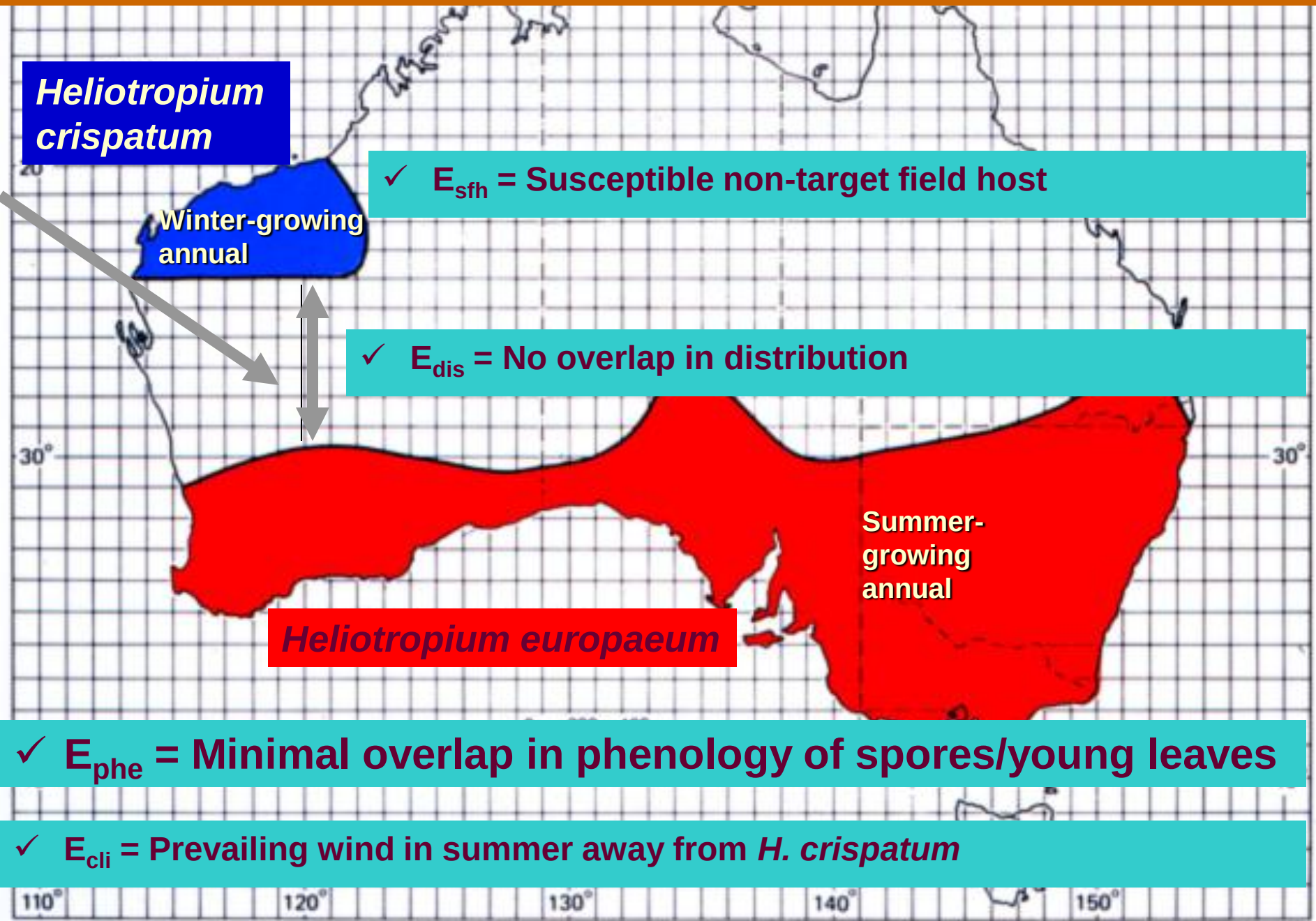
A Complex Example

- **Two H_i character states:**
  - ✓ H_{phr} = physiological host range; and
  - ✓ H_{bbf} = basic biological features.
- **Four E_p character states:**
  - ✓ E_{sfh} = susceptible non-target field hosts;
  - ✓ E_{dis} = distribution;
  - ✓ E_{phe} = phenology; and
  - ✓ E_{cli} = climate.

Risk from *U. heliotropii*

- H_{phr} and H_{bbf} both indicate very low hazard;
- E_{sfh}, E_{dis}, E_{phe} and E_{cli} all indicate very low exposure; and
- Risk = $(H_{phr})(H_{bbf}) \times (E_{sfh})(E_{dis})(E_{phe})(E_{cli})$.
  $(\sim 0)(\sim 0) \times (\sim 0)(\sim 0)(\sim 0)(\sim 0)$
- $\therefore$ Risk = pretty darn close to zero!

Exposure analysis for *Uromyces heliotropii*



Discussion Topics

- What changes are needed to improve physiological host-specificity testing?
- How can modern genetic techniques improve the pre-release procedures?
- Can efficacy actually be predicted by physiological host-specificity testing?
- Is it necessary to predict efficacy—isn't a solid prediction of specificity enough?
- Is it ethical to conduct a biological control program if a detailed, long-term field monitoring program is not planned?
- What data will convince regulators?

Discussion

Risk: A Matrix of Possibilities

Hazard	Exposure: Low No species in the same genus	Exposure: High Many species in the same genus
Low Monophagous agent (e.g., *Puccinia chondrillina)*	**Low Risk**	**Probably Low Risk**
High Polyphagous agent (e.g., *Dialectica scalariella)*	**Probably Low Risk**	**High Risk**